# Towards the South African Underground Laboratory

UNIVERSITEIT STELLENBOSCH UNIVERSITY

NRF National Research Foundation | iThemba LABS Laboratory for Accelerator Based Sciences

## Collaboration


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RESPICE PROSPICE

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SPES BONA

EARTH

# Outline

- Introduction
- Underground Physics in SA
- Location of SAUL
- Huguenot Tunnel Survey
- Intended projects and strategy

# Introduction

- Discussions about an underground research facility in SA started in 2011.
- South Africa has a number of the worlds deepest gold mines (**TauTona Gold Mine ~3.9 km**)
- Initial focus was on establishing an underground facility in one of South Africa's deep gold mines.
- The alternative is to develop such an underground laboratory inside the Huguenot Tunnel.

# EVIDENCE FOR HIGH-ENERGY COSMIC-RAY NEUTRINO INTERACTIONS*

F. Reines, M. F. Crouch, T. L. Jenkins, W. R. Kropp, H. S. Gurr, and G. R. Smith

Case Institute of Technology, Cleveland, Ohio

and

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University of the Witwatersrand, Johannesburg, Republic of South Africa

(Received 26 July 1965)

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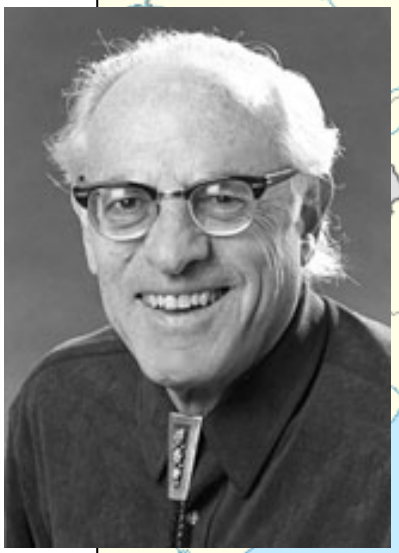
The flux of high-energy neutrinos from the decay of $K$, $\pi$, and $\mu$ mesons produced in the earth's atmosphere by the interaction of primary cosmic rays has been calculated by many authors.[1] In addition, there has been some conjecture[1] as to the much rarer primary flux of high-energy neutrinos originating outside the earth's atmosphere. We present here evidence[2] for the interactions of "natural" high-energy neutrinos obtained with a large area liquid scintillation detector (110 $m^2$) located at a depth of 3200 m (8800 meters of water equivalent, average $Z^2/A \simeq 5.0$) in a South African gold mine.

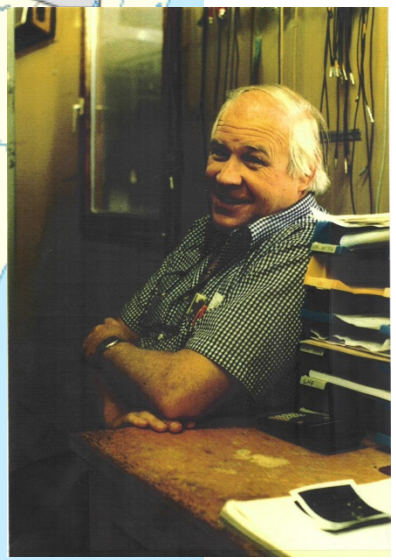
array is grouped into 6 "bays" of 6 elements

FIG. 1. Schematic of detector array.

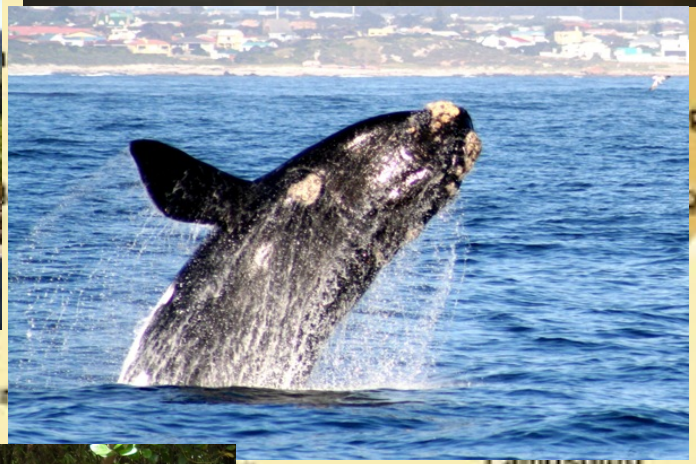




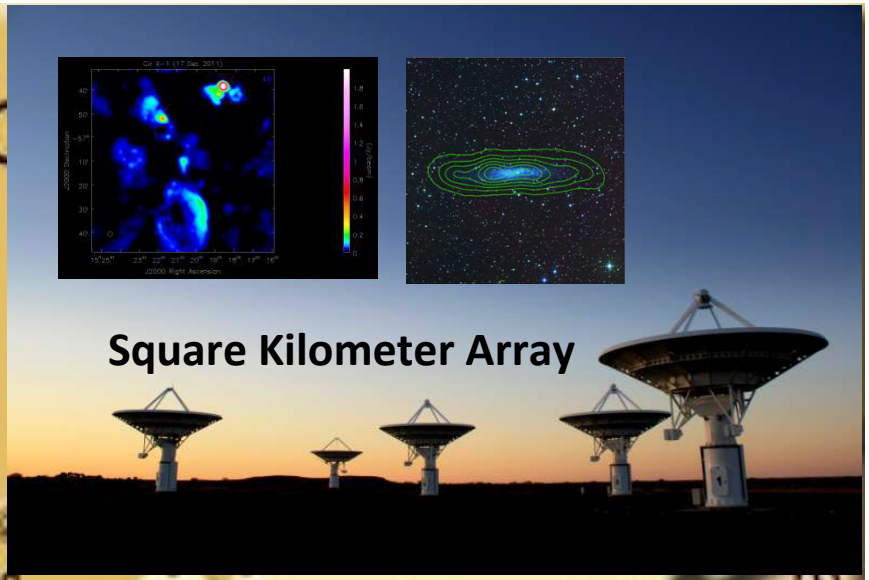
Frederick Reines



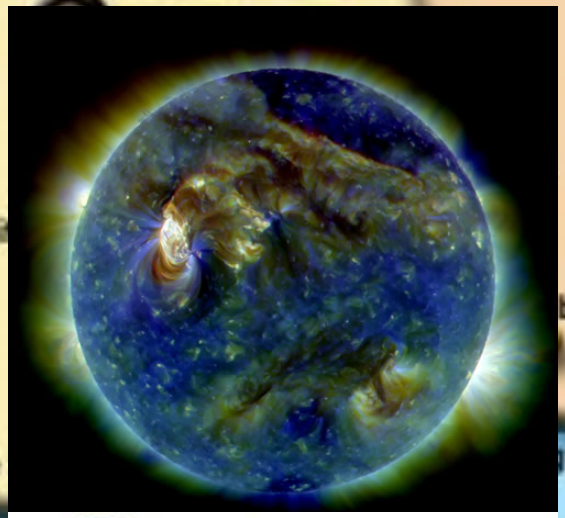
Friedel Shellschop




Touws River
Worcester
Montagu
nbosch
Swellendam
Caledon
Riversdale
Bredasdorp





sansa
SOUTH AFRICAN NATIONAL
SPACE AGENCY

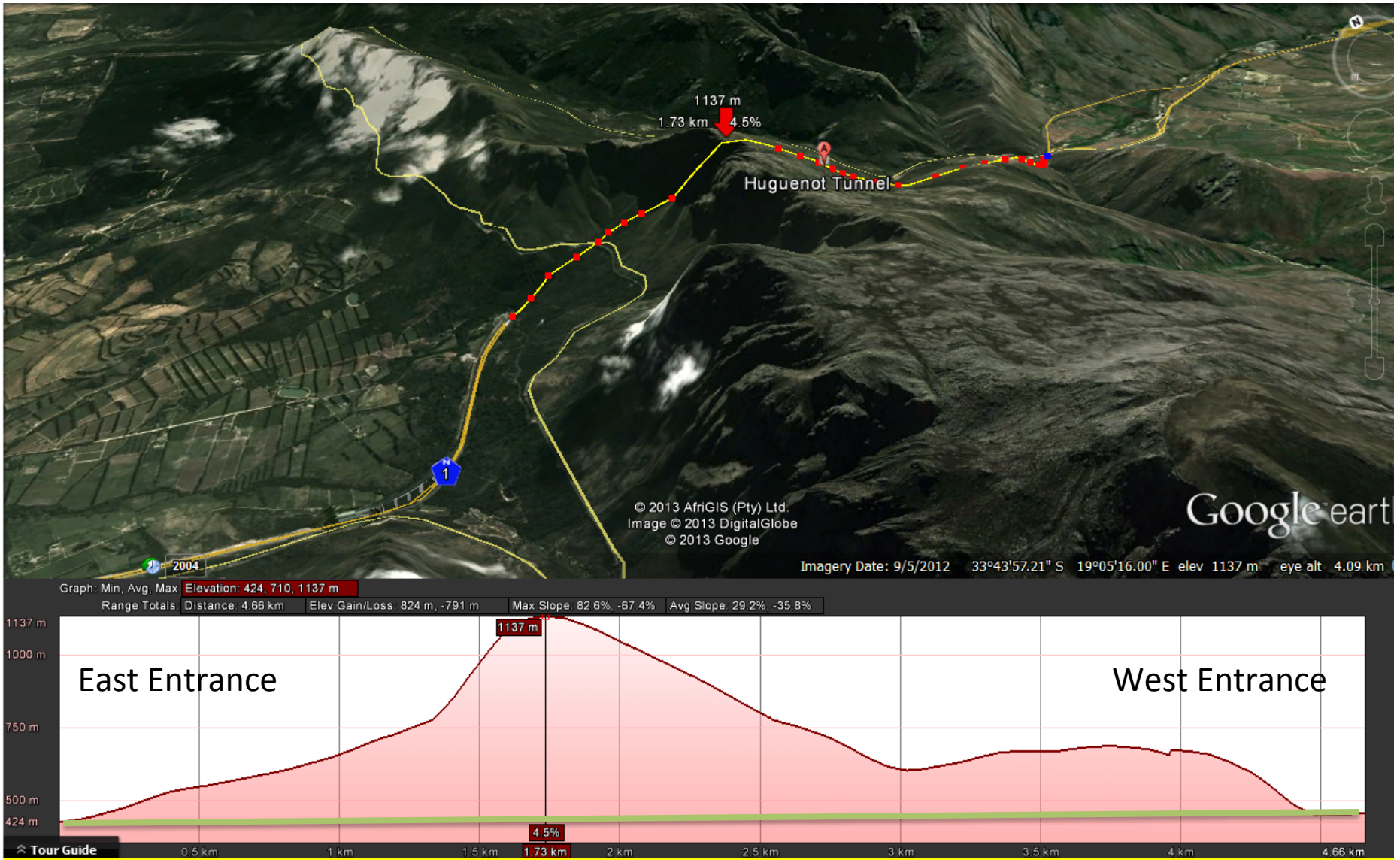
# World Class Universities


Stellenbosch University

University of Cape Town

University of the Western Cape


Koeberg Nuclear Power plant
Huguenot Tunne
60 km
25 km
Wellington
Bellville
Cape Town
Cape Town
Stellenbosch
Mitchells Plain
Somerset West
Fish Hoek
Grabouw
© 2013 Google
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 AfriGIS (Pty) Ltd.
Google earth
Imagery Date: 4/10/2013 34°00'12.74" S 18°36'19.67" E elev 37 m eye alt 99.10 km




The range mostly consists of Table Mountain sandstone, an erosion-resistant quatzitic sandstone

# Huguenot Tunnel survey
# 05 April 2013

PP Maleka[1], NB Ndlovu[1,2], RT Newman[2], S Tshingana[1], M Van Rooy[1,2]

1. iThemba LABS
2. Stellenbosch University



National Research Foundation | iThemba LABS Laboratory for Accelerator Based Sciences

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The view from the outside of the tunnel (Cape Town end)

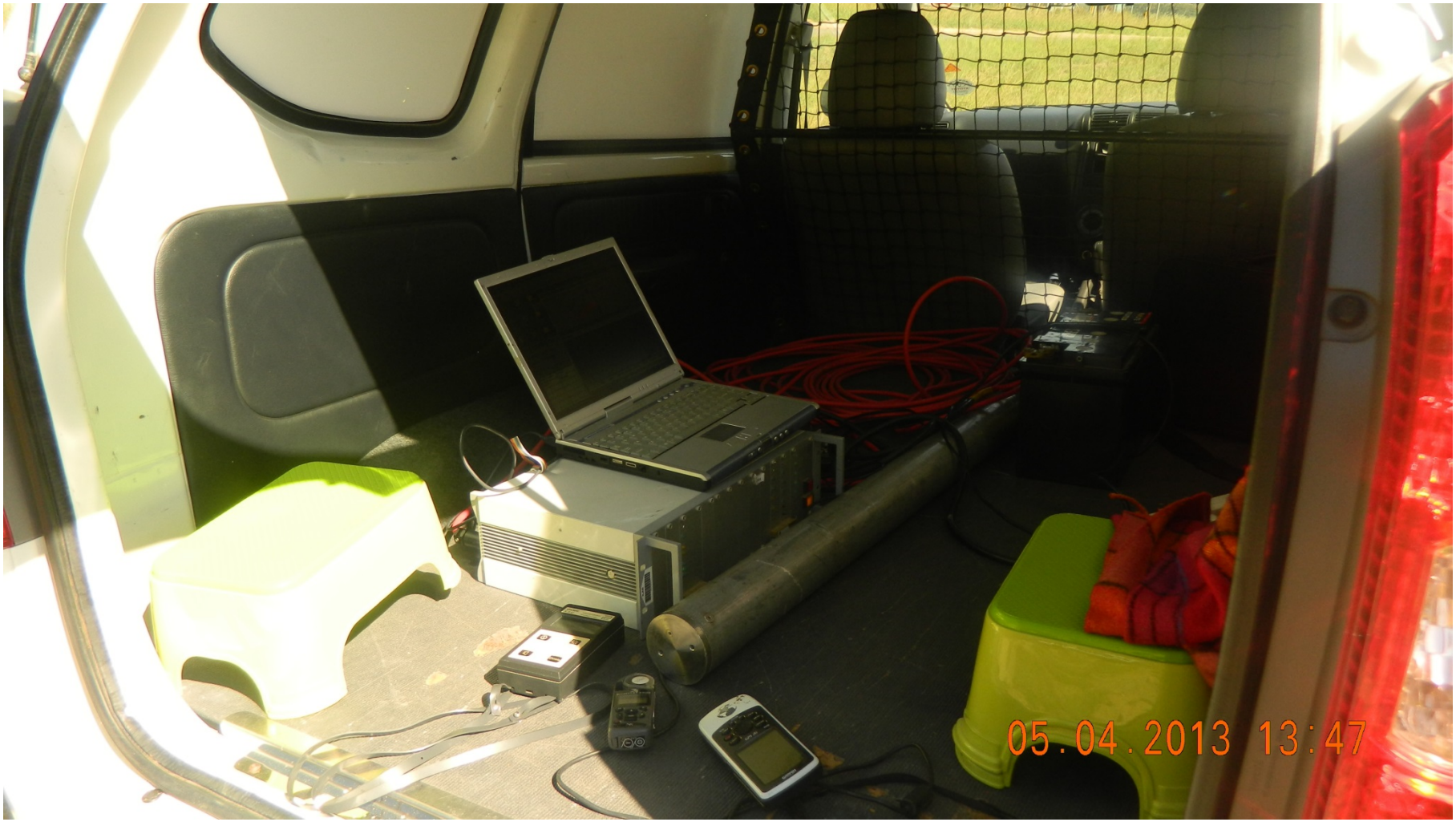
The picture view of the tunnel

Picture view of one of the VCC (Vehicle Cross-Cut), electret were deployed close by

The team; Zina, Milton, Richard and Siya

MEDUSA (multi-element detector using a scintillator array) setup for gamma-ray mapping

Picture view of the MEDUSA setup



GAMMAN (v1.17.52.440) - [default.gsf] - Detector ID [SSU472_RHO21.W]

File Edit View Processing Tools Help

Open | Data view | Selection | Process all | Plot | Plot settings... | View log

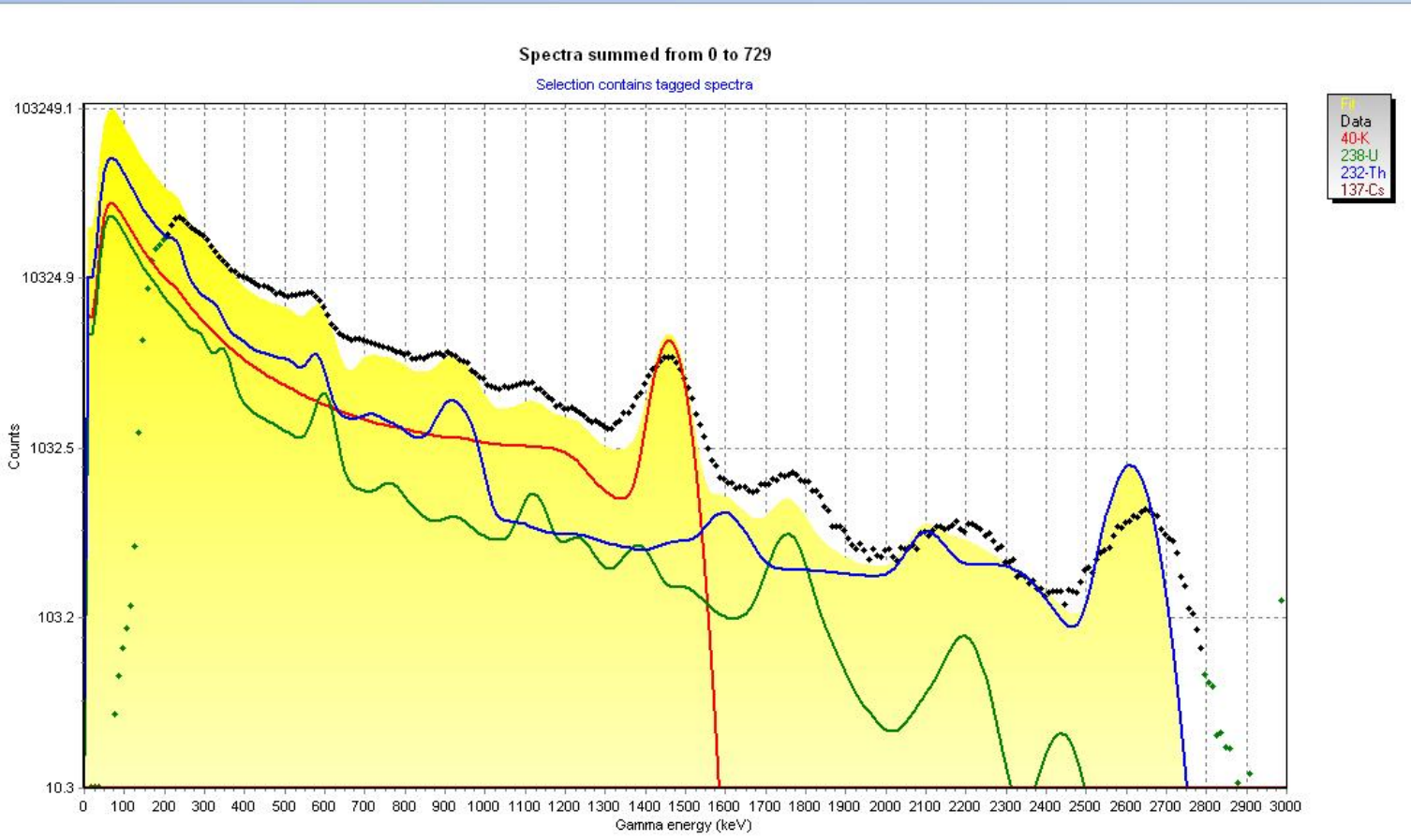
## Concs (Bq/kg)

| Fitresult | Value |
|---|---|
| 40-K | 1892.17 |
| 238-U | 83.48 |
| 232-Th | 152.98 |
| 137-Cs | -28.47 |
| S 40-K | 8.91 |
| S 238-U | 1.05 |
| S 232-Th | 0.38 |
| S 137-Cs | 1.01 |
| Countrate | 567.87 |
| S Cts | 0.62 |
| Chi2 | 16.39 |
| Stab | 0.88 |

Concs (Bq/kg)

Stabilization

Settings

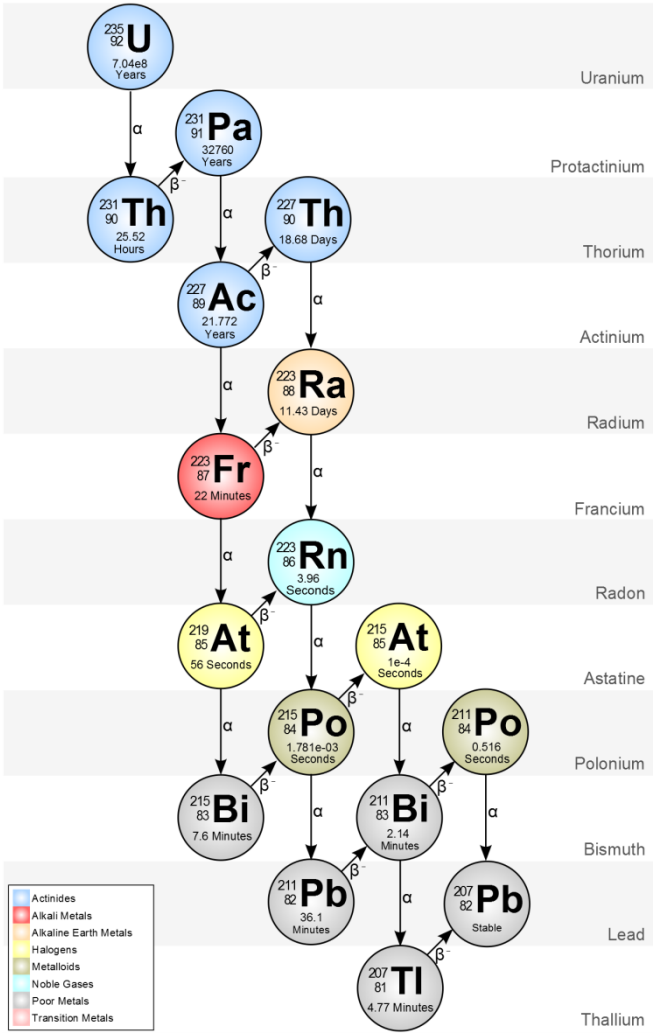



Raw data | Processed data

| Spectrum No | Date&time | Logfilename | Logfileno | Pressure_5c | Sound_5c | Temp_5c | Spectrum51 | Total_counts | Cable_volt_5 | Cable length | Stab |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 721 | 41369.692762 | -1.000000 | 2.000000 | -1.430664 | 0.750732 | 37.737343 | 1.999451 | 826.763489 | 82.123184 | 0.000000 | 0.891000 |
| 722 | 41369.692785 | -1.000000 | 2.000000 | -1.467285 | 0.753784 | 37.717522 | 1.999451 | 797.717834 | 82.123184 | 0.000000 | 0.891000 |
| 723 | 41369.692809 | -1.000000 | 2.000000 | -1.320801 | 0.749207 | 37.717522 | 1.998413 | 791.060303 | 82.123184 | 0.000000 | 0.891000 |
| 724 | 41369.692832 | -1.000000 | 2.000000 | -1.229248 | 0.752258 | 37.734512 | 2.000488 | 761.410767 | 81.688095 | 0.000000 | 0.891000 |
| 725 | 41369.692855 | -1.000000 | 2.000000 | -1.357422 | 0.749207 | 37.726017 | 2.000488 | 766.597534 | 82.123184 | 0.000000 | 0.891000 |
| 726 | 41369.692878 | -1.000000 | 2.000000 | -1.192627 | 0.750732 | 37.737343 | 1.999451 | 737.551880 | 81.688095 | 0.000000 | 0.891000 |
| 727 | 41369.692901 | -1.000000 | 2.000000 | -1.320801 | 0.779724 | 37.717522 | 1.999451 | 794.178772 | 82.123184 | 0.000000 | 0.891000 |
| 728 | 41369.692924 | -1.000000 | 2.000000 | -1.284180 | 0.756836 | 37.714691 | 1.999451 | 803.738342 | 82.123184 | 0.000000 | 0.891000 |

Registered to: ITHEMBA LABSRSA | Data in Bq/kg | GAMMAN. *When every count counts...*

# Radon Monitoring



# Experimental Methods

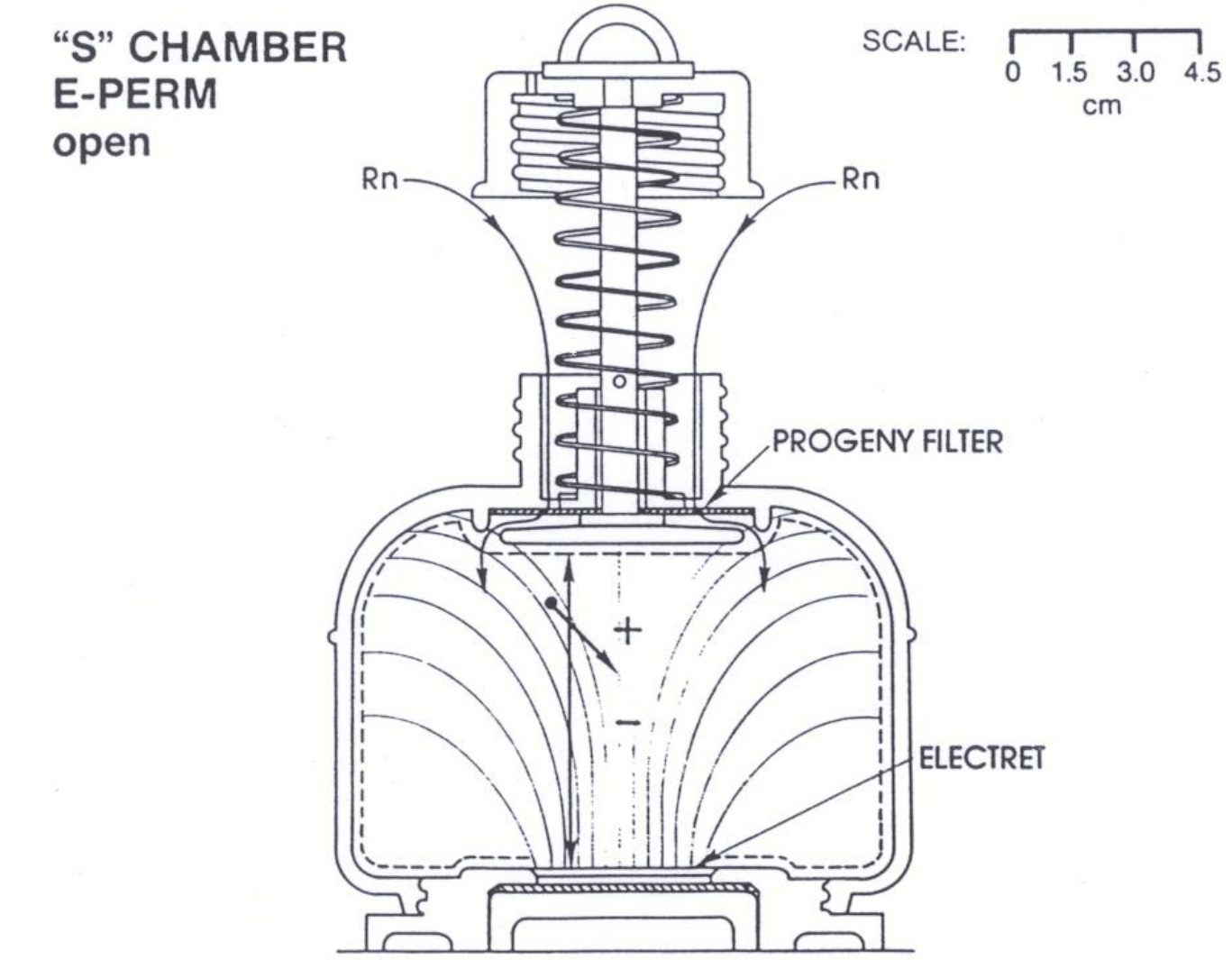
- Use electrets (charged Teflon disks) inserted in ion chambers –

E-PERM system

# Electret Passive Environmental Radon Monitor (E-PERM)

(Kotrappa et al. Health Phys. Vol. 58, no. 4, p.461)

# Schematic of radon detector open showing electric field lines



# Experimental Methods

- Radon decay in chamber ionizes air and electret charge is reduced with exposure (level, time)

- Measure voltage for electrets before and after exposure (~ two week period)

# Determining radon concentration

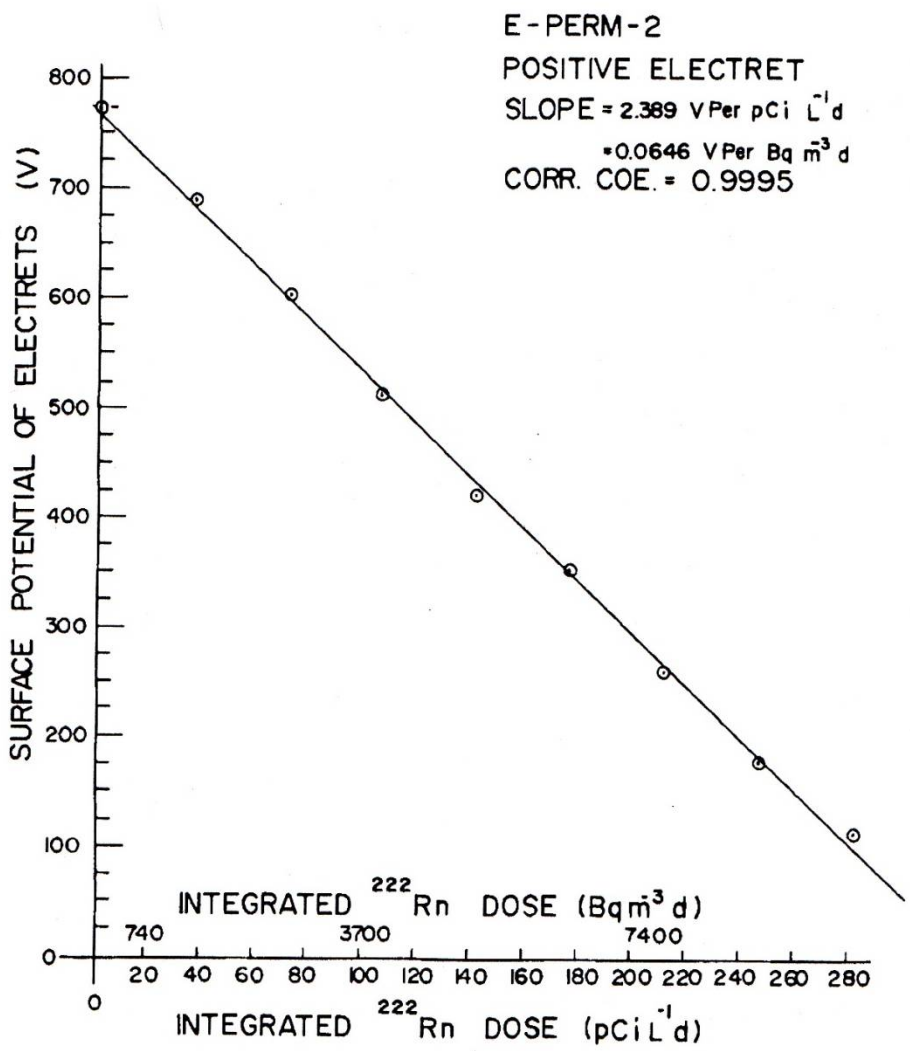



Fig. 4. Dose response relationship for E-PERM-2.

# Field work

- Placed 3 Electret Ion Chambers at 3 locations (VCC [vehicle cross-cut]) along tunnel.

- Placement/collection date: 5 April/17 April

- Locations are close to possible sites for future experimental stations

Electret being deployed

# Data Analysis

- Assume standard background (due to for example gamma-ray radiation) of 32 $Bq.m^{-3}$ (air radon concentration)

- This background factor will be measured in future

# Results

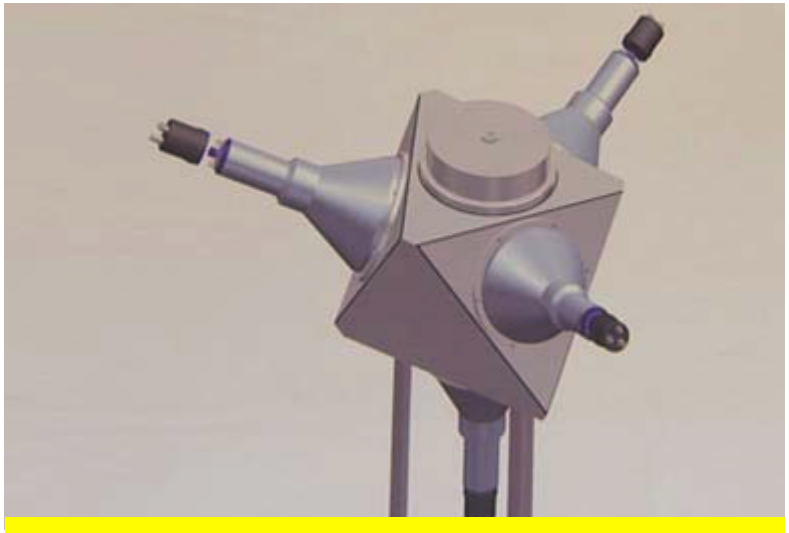
| | Mean | Standard Deviation |
|---|---|---|
| location | Air Radon Concentration | Air Radon Concentration |
| | ($Bq.m^{-3}$) | ($Bq.m^{-3}$) |
| VCC1 | 45.4 | 0.1 |
| | | |
| **VCC2** | **52.7** | **7.1** |
| | | |
| VCC3 | 64.9 | 5.2 |
| | | |

Biomonitor samples deployment in main tunnel for Zina Ndlovu

Picture view of the deployed samples

# Earth AntineutRino TomograpHy project

- Development of directional sensitive anti-neutrino detectors.

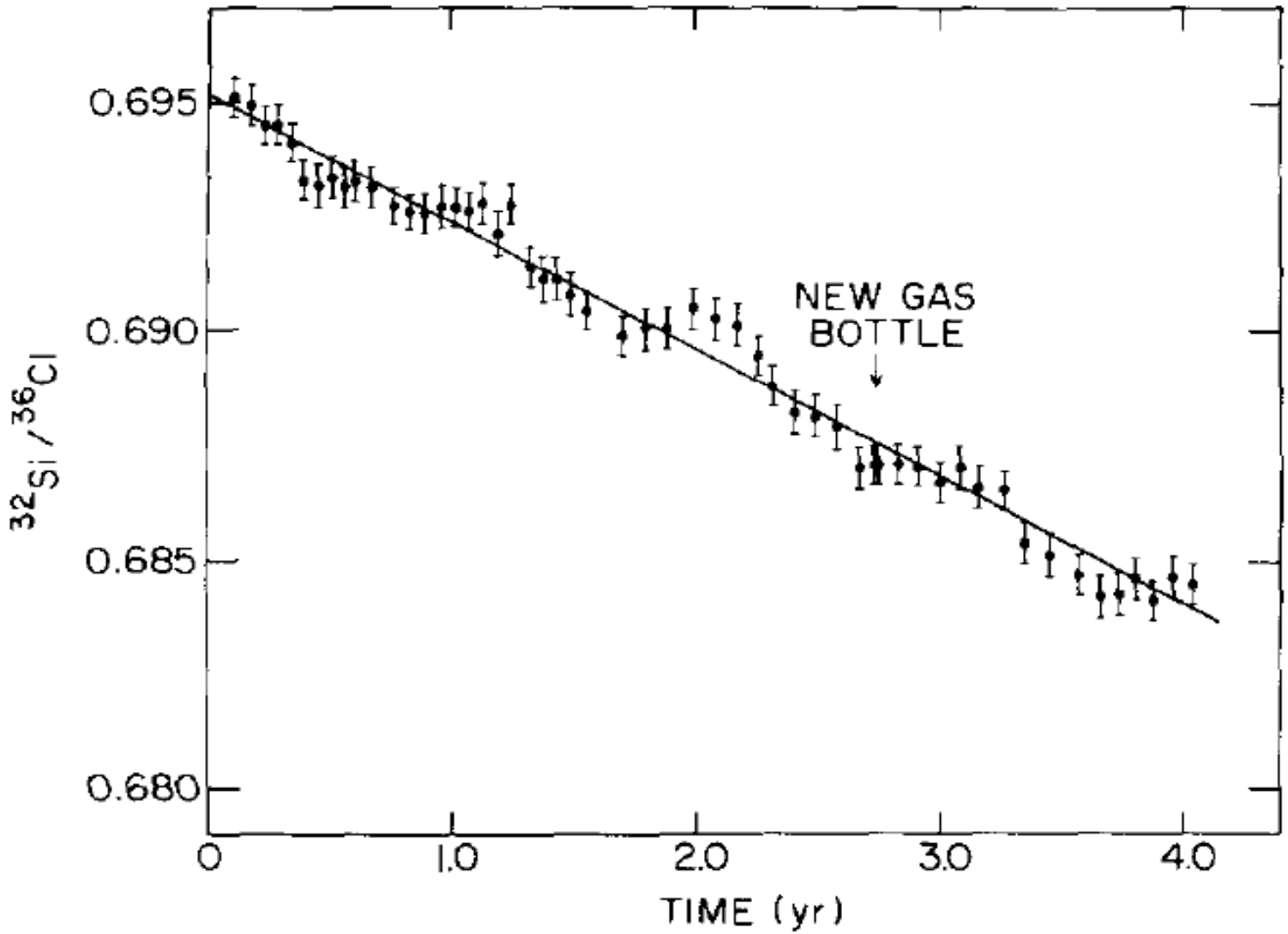


Geoneutrinos in ZA (GiZA) detector

- Suitable for tests at a nuclear power plant. Volume 36 litres.
- Equipped with state of the art scintillation material and photon detection.
- Status:

1. Light transport simulated,
2. Mechanical design completed.
3. Acquiring finances and access permission

*Oscillations in the decay rate of $^{32}Si$ observed by Alburger et. al [2].Similar oscillations claimed by Jenkins et al [3] to be correlated with changing seasonal solar neutrinos flux.*




[1] Alburger et al., 1986, Half-life of $^{32}Si$, Earth and Planetary Science Letters **78**, p168-176.
[2] Jenkins, J.H., Fischbach, E., Buncher, J.B., Gruenwald, J.T., Krause, D.E., Mattes, J.J.: 2009, Evidence of correlations between nuclear decay rates and Earth-Sun distance. *Astroparticle Physics* 32(1), 42.

# Current Projects (2013)

- Radon-in-Air measurements in the Northern bore using Electret Ion Chambers to monitor Radon continuously.
- Gamma-ray measurements along the length of the northern bore as well as outside the tunnel with the MEDUSA scintillator detector.
- Long term (~one month) Gamma-ray measurement inside and outside the tunnel.
- Measurement of Cosmic ray background both inside and outside the tunnel (muon measurement starting in November 2013)

# Strategy

Following the current feasibility study a small workshop (Stellenbosch ~March 2014) with the South African Department of Science, South African Roads Agency Limited (SANREL), potential role players (SA Universities, iThemba LABS and International community)

- Enter discussions to have a permanent facility in place within the tunnel (**request letters of support**).
- Develop established programs in the studies of double beta decay, geoneutrinos, dark matter, etc.
- Exchange of knowledge, skills and the training of young people.

English: **Thank you**
Afrikaans: Dankie
IsiNdebele: Ngiyathokoza
Sesotho: Ke a leboha
Northern Sotho: Ke a leboga
Setswana: Ke a leboga
SiSwati: Siyabonga
Xitsonga: Inkomu
Tshivenda: Ndo livhuwa / Ro livhuwa
IsiXhosa: Enkosi
IsiZulu: Ngiyabonga

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